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Representational pseudoneglect and reference points both influence geographic location estimates

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Abstract

Our mental representation of the world is far from objective. For example, western Canadians estimate the location of North American cities to be too far to the west. This bias could be due to a reference point effect, in which people estimate more space between places close to them than far from them, or to representational pseudoneglect, in which neurologically intact individuals favor the left side of space when asked to image a scene. We tested whether either or both of these biases influence the geographic world representation of neurologically intact young adults from Edmonton and Ottawa, which are in western and eastern Canada, respectively. Individuals were asked to locate North American cities on a two dimensional grid. Both groups revealed effects of representational pseudoneglect in this novel paradigm but they also each exhibited reference point effects. These results inform theory in both cognitive psychology and neuroscience.

Representational pseudoneglect and reference points both influence geographic location estimates

In cognitive psychology and human geography, it is well established that people have regionalized, hierarchical representations of the world (Friedman, 2009; Friedman & Brown, 2000a,b; Friedman, Kerkman, Brown, Stea, & Cappello, 2005; Friedman & Montello, 2006; Stevens & Coupe, 1978). For example, when people estimate the latitudes of cities they divide space into regions that do not overlap and are not necessarily coincident to political borders. Such estimates reveal relatively large gaps between regions that do not reflect the north-south intermingling of actual borders; the bias in the north-south estimates increases as the cities being estimated are actually further south; and the regions can be influenced independently, depending upon whether they are "conceptually coordinated" (Friedman & Brown, 2000b). These findings have been obtained with subjects who live in very different parts of North America (Friedman et al., 2005), using both numeric (Friedman & Brown, 2000a, b; Friedman & Montello; 2005) and spatial (Friedman, 2009) response modes.

However, only the spatial response mode revealed how people placed cities on both latitude and longitude dimensions simultaneously and the only subjects who have done so were western Canadians (Friedman, 2009). Whereas latitude estimates were again biased too far to the south, longitude estimates were biased too far to the west and there was more "space" between western than eastern Canadian cities. The latter bias could have arisen because subjects were more familiar with western Canadian cities and/or a reference point near them (e.g., the Rocky Mountains). For example, Holyoak and Mah (1982) showed that Californians rated the magnitude of the imagined difference in east-west distance between two cities close to a reference point (e.g., the Pacific Ocean) to be greater than that between cities that were far from the reference point, even though the distances were actually equal. When a different group of Californians were asked to imagine they were on the east coast, the opposite result obtained: The east-west difference between cities close to the Atlantic Ocean was greater than between western cities. Holyoak and Mah proposed that stimulus magnitudes that are closer to a reference point are easier to discriminate from each other than magnitudes that are far from it. The use of the reference point construct is ubiquitous across many areas of psychology (e.g., Kahneman and Tversky, 1979). Thus, the western bias in Friedman's (2009) data might have been due to where the subjects happened to live (i.e. Edmonton).

There is another possibility, however: the neuropsychological phenomenon of *hemispatial neglect*, which occurs in both patient populations and healthy individuals. A vast literature documents this condition in patients with damage to mainly the right hemisphere; they demonstrate a deficit in directing their attention towards the left hemispace (for recent accounts, see Adair & Barrett, 2008; Verdon, Schwartz, Lovblad, Hauert, & Vuilleumier, 2010). For example, when patients with neglect judge the subjective midpoint of a horizontal line they place their bisections to the right of the objective midpoint, as if they are ignoring the left side of space or are hypersensitive or more attentive to the right side of space. Even when asked to place familiar cities on a map of England (where this particular patient had lived), all of the cities were placed on the east coast of the map (Critchley, 1962). Similarly, a French patient with hemispatial neglect placed all the cities in France on the east side of a map that was aligned with his body axis (Rode, Cotton, Revol, Jaquin-Courtois, Rossetti, & Partolomeo, 2009). These data are relevant to the present study because they illustrate that even when people are limited by the true boundaries of a given space, they exhibit hemispatial neglect. Absence of co-existing contralateral peripheral sensory or motor loss suggests that the impairment involves higher level processes. In fact, it has been shown that pre-attentive processing up to the level of meaning can take place in the neglected field without conscious awareness (e.g., Driver & Vuilleumier, 2001; Vallar, 1998).

Further evidence that neglect involves higher level processes comes from studies on *representational neglect*, in which there is a deficiency of attention to the left side of *imagined* space. The seminal demonstration was reported by Bisiach and Luzzatti (1978): When asked to image (eyes closed) and then describe the Piazza del Duomo in Milan, neglect patients reported far fewer landmarks on the left than on the right side. Famously, when asked to image the same Piazza from its opposite side, the phenomenon was the same: far fewer landmarks were reported on the left side (see also Rode et al., 2009). This finding is similar to Holoyak and Mah's (1982), and implies that the imagined representation must have been "whole", but the processes used to read from it were impaired. Later work extended the findings to imagining the map of a country from a particular view (e.g., from the north vs. the south; Rode and Perenin, 1994) and to more abstract spatialized stimuli (the number line; Vuilleumier, Ortigue, & Brugger, 2004; Zorzi, Priftis, & Umilta, 2002).

Of relevance to the present study, in neurologically intact individuals, perceptual and imagined space are both also biased along the horizontal axis, but opposite to the side of patient populations. For example, when performing line bisections healthy individuals show a slight but consistent bias to locate the subjective midpoint to the left of true center (thus ignoring the *right* side of the paper). This hemispatial bias is known as *pseudoneglect* (Bowers & Heilman, 1980; Jewell & McCourt, 2000) and is also thought to be modulated by higher level processing (Mohr & Leonards, 2007). Finally, with respect to imagined space and *representational pseudoneglect,* McGeorge, Beschin, Colnaghi, Rusconi, and Della Sala (2007) replicated the Bisiach and Luzzati experiment with healthy individuals who showed a bias to report fewer landmarks from the *right* side of the imagined scene (see also Loetscher and Brugger, 2007).

In the present study, our goal was to explore the two possible explanations of the Edmontonian geographical estimates: (a) that the westward bias was due to a reference point effect, or (b) that it was due to representational pseudoneglect. We tested one group from Edmonton, Alberta (longitude 113° W) and a second from Ottawa, Ontario (longitude 76° W), who both made spatial location estimates of cities in North America. If the leftward bias of Edmontonians was due to a reference point effect alone, then we should see the opposite result in the Ottawans; that is, a rightward bias and more space between eastern than western cities. This finding would have potential consequences for current neuropsychological theories of neglect. For example, if Ottawans show a reference point effect, it cannot be that they are completely neglecting the right-sided semantic or spatial information that implicitly or explicitly played a role in their responses. In contrast, if the previously observed leftward bias is due strictly to representational pseudoneglect, then we should see a similar leftward bias in the Ottawans' data. This would have potential consequences for any cognitive theory of location estimation. For example, if representational pseudoneglect causes part of the observed longitudinal bias, then theories of geographical location estimates that consider only metrics and mapping (Brown & Siegler, 1993) or placing regions with respect to global landmarks (Friedman & Brown, 2000a,b) must be augmented to account for this neuropsychological factor. Finally, the processes may not be mutually exclusive: We could plausibly find evidence for both. For example, familiarity with one's home region could plausibly underlie the reference point effect, which could thus manifest itself even if a person also displayed pseudoneglect. A priori, we presume these are different mechanisms, but even so, they may both be present.

It should be noted that for tasks that reveal representational neglect (neglecting the left side) or representational pseudoneglect (neglecting the right side) the assumed reference point is considered to be a body-centered one. For example, in the line bisection task or previous map-based tasks, the line or map is assumed to be anchored to the subject's body-centered view (e.g., Rode et al., 2009). Indeed, the paper to be drawn on in both cases is centered in front of the subjects, as is the computer screen in the present case. It is for this reason that we predict a westward shift (i.e., pseudoneglect) for both groups if, in fact, the westward shift is a manifestation of pseudoneglect. The theoretical and empirical question is whether the Ottawans will show a leftward (pseudoneglect only) or rightward (reference point only) shift, or whether instead they will have more space between eastern than western cities yet at the same time show a western bias for most cities (including their own). The latter finding would indicate that both phenomena were underlying the estimates.

Method

Subjects: Demographics and handedness. Thirty-two volunteers (15 females) drawn from the University of Alberta's Psychology subject pool (Edmonton, Alberta, Canada) received part credit for their participation. Twenty-seven subjects were right-handed and the remaining 5 were either ambidextrous or left-handed, according to a standardized handedness questionnaire (Oldfield, 1971). We examined handedness because it is an important factor in many cognitive asymmetries, although a recent meta-analysis of pseudoneglect (Jewell & McCourt, 2000) showed that the effect was small on bisection errors, with right-handers erring slightly more to the left than left-handers. We wanted merely to assure that the proportions were similar in both groups.

Thirty volunteers (15 females) drawn from the Carleton University Psychology subject pool (Ottawa, Ontario, Canada) received part credit for their participation. The present study was a "filler task" for a second, unrelated study about mathematical skills. Twenty-five subjects were right-handed and 5 were either ambidextrous or left-handed. Thus, the proportion of right- and left-handed individuals was approximately the same in each group, but there were too few left-handers to analyze separately.

Stimuli, design, and procedure. Subjects in both cities estimated the locations of 18 Canadian cities and 9 cities from each of the northern and southern U.S. and Mexico. Table 1 lists the cities and their actual latitudes and longitudes and Figure 1 shows their actual locations. To test the main hypotheses, we were primarily interested in the longitude estimates for the Canadian cities; however, tests of the other regions were of interest for comparison to past research (e.g., Friedman, 2009; Friedman & Brown, 2000a,b).

After signing a consent form, all subjects were seated in front of a computer monitor with 1024 x 768 pixel resolution. The latitude x longitude grid used the full 180^{o} range of longitudes, from 0^{o} (Greenwich, England) to 180^{o} (Pacific Ocean). This is important because if subjects were merely trying to utilize all the space available to them, then we would expect them to center their responses at about 90^{o}W. The latitudes on the grid ranged from 90^{o}N (North Pole) to 40^{o}S (about 6^{o} south of Buenos Aires, Argentina). A "use all the space" strategy would thus center the cities at about 65^{o}N. Each "box" in the grid was square and was labeled every 10^{o} of latitude/longitude.

Subjects first performed a knowledge rating task to familiarize them with the set of cities they would be rating. The task specifically asked about general knowledge about each city, not specifically spatial knowledge. On each trial, the name of a city, its state/province, and country was presented on the monitor and the subject responded by using the number pad to enter numbers from 0 (no knowledge) to 9 (a lot of knowledge).

Next, subjects were instructed about how latitudes and longitudes work. On each trial of the estimate task, an empty latitude by longitude grid appeared, along with the name of a city, its state or province, its country, and an *X* at the top of the grid. The subject dragged the *X* to the place on the grid where he or she thought the city was located. There were no time constraints. The subject pressed the “Enter” key and the next trial began. Each subject received a different random order of cities for both the knowledge rating and estimate tasks.

When the estimation task was finished, the subjects filled out the handedness questionnaire and answered two multiple choice questions about the northern- and southern-most latitudes of North America, for comparison to previous research. The alternatives included the full latitude range, from 90^o to -90^o, in 10^o steps, with the equator identified as such.

Results and Discussion

For all statistical tests we used $p < .05$ as the significance level, η_p^2 as the measure of effect size, and 95% confidence intervals (*CI*) on the means computed from the within-subjects error term (Masson & Loftus, 2003) as the measure of variability. Figure 2 shows the data. It is apparent that the latitude estimates replicated characteristics of results we have obtained many other times (Friedman & Brown, 2000a,b; Friedman et al., 2003; Friedman & Montello, 2006) and that there was evidence for both reference point effects and the traditional, body-centered effect of representational pseudoneglect.

Analyses of signed errors. We computed a signed error for both the latitude and longitude estimates for each city and subject by subtracting the estimated value from the actual value. On the north-south dimension, negative numbers are too far south; on the east-west dimension they are too far west because in the western hemisphere longitudes are signed negatively.

For latitudes, a group by region analysis of variance (ANOVA) yielded only a main effect of region, $F(3,180)=60.61$, $\eta_p^2=.503$ (all other Fs< 1.0). The mean values for estimates of cities in Canada, the northern United States, the southern United States, and Mexico were -0.04^o, -12.40^o, -14.40^o, and -24.42^o ($CI \pm 3.53^o$), respectively, replicating our previous results. Errors for both groups became too far south as the cities being estimated were actually located farther south. The groups also did not differ with respect to where they thought the northern and southern borders of North America were: Only the main effect of north/south was significant, $F(1,60)=243.21$, $\eta_p^2=.802$. On average, both eastern and western Canadians thought the northern border of North America was at 77.1° and the southern border was at -6.5° (95% *CI* ± 10.70°). Thus, all of our previous results with latitude estimates were replicated with both groups here.

To test for representational pseudoneglect, we conducted two analyses of the signed errors in longitude estimates. The first used all the estimates from the four north-to-south regions and the second used only the eight furthest west and seven furthest east Canadian cities (see Table 1), which we also used to test the reference point hypothesis.

For the analysis of all the cities, there was only a main effect of region, $F(3,180)=3.94$, $\eta_p^2=.062$; all other Fs < 1.0. The means for all the cities in each of the four regions, beginning with Canada, were -9.27°, -7.31°, -9.18°, and -14.81°, respectively (*CI* ± 4.54°). The signed errors for both groups were all negative and thus all too far to the west. From Figure 2, it can be seen that neither the latitudes nor the longitudes were centered on the grid, so it is doubtful that subjects were using a "fill the space" or "center the space" strategy. Rather, it is more likely that the data were due to representational pseudoneglect by both groups.

The analysis of signed errors for the average signed error of the seven most eastern and eight most western Canadian cities also showed only a main effect of region, $F(1,60)= 24.06$, $\eta_p^2=.286$. The means for the eastern and western cities were -1.47° and -16.11°, respectively (*CI* ± 5.54°).

Reference point analyses: Estimated distances and knowledge ratings. For the analysis of the reference point effect, we first computed (from the location estimates) the estimated distance in kilometers for each possible pair of seven eastern Canadian cities and eight western cities, using the haversine formula, which computes the great circle distance between two points. We then averaged these distances over eastern and western cities for each subject and conducted a group by east/west mixed ANOVA. Only the interaction was significant, $F(1,60)=6.68$, $\eta_p^2=.100$. The Edmontonians estimated the average distance between cities in the west vs. east as 1,685 km vs. 1,487 km, whereas the Ottawans estimated the average distance as 1,763 km vs. 1,975 km, respectively, ($CI \pm 158.27$ km). Thus, this was a crossover interaction, as would be predicted by the reference point hypothesis. The simple main effect between regions was significant for Edmonton, $F(1,31) = 5.33$, $\eta_p^2=.147$, but not Ottawa, $F(1, 29) = 2.43$, $\eta_p^2 =.077$, $p = .13$, although the effect size was moderate, the means were in the right direction, and the order of magnitude of difference was virtually identical to Edmonton's. The actual distances between all pairs of seven eastern and eight western cities was 891 km and 823 km, so subjects were overestimating in general.

We next averaged the knowledge ratings for the seven eastern and eight western Canadian cities and analyzed them using the same design as the distances. There was a main effect of region, $F(1,60)=85.88$, $\eta_p^2=.589$, and a region by group interaction, $F(1,60)=484.075$, $\eta_p^2=.890$. Edmontonians rated themselves as knowing more about western Canadian cities (5.81) than eastern Canadian cities (4.12) and Ottawans rated themselves as knowing more about eastern Canadian cities (6.42) than western Canadian cities (2.27), $CI \pm 0.265$. The simple main effects were significant for both groups: for Edmonton, $F(1, 31) = 119.25$, $\eta_p^2=.794$, and for Ottawa, $F(1, 29)=359.36$, $\eta_p^2=.925$. This finding supports the idea that the reference point effect can be supported by actual familiarity and not only the mental point of view taken by the subjects, or even discriminability per se. It also supports the idea that the reference point effect is likely to be independent of the effects due to pseudoneglect. The notion of independence is also supported by one of Rode et al.'s (2009) findings: their hemispatial neglect patient did not have trouble naming cities from the west of France but did have trouble placing them correctly on a real or imagined map.

It is important to reiterate that subjects saw the entire grid from 0^{o}-180^{o}W on each trial. Thus, if they were trying to "center" their responses on the grid, their average longitude should have been about 90^{o}. However, for both groups the average estimates were significantly west of 90^{o} by about the same amount: For the Edmontonians the mean estimate was 110.08^{o}, $t(31) = 5.99$, $CI = 6.88^{o}$, and for the Ottawans it was 109.48^{o}, $t(29) = 5.38$, $CI = 7.40^{o}$.

General Discussion

The data from the present study show that both reference points and representational pseudoneglect affect biases in geographic location estimates. First, the evidence for the reference point effect was that there was more space between western than eastern cities for the Edmontonians and the reverse was true for the Ottawans. Equally, knowledge ratings were higher for western than eastern cities for the Edmontonians and the reverse was true for the Ottawans. Second, both eastern and western Canadian university students displayed evidence of representational pseudoneglect in this new hemispatial attention paradigm in which subjects had to estimate from memory the spatial locations of eastern (right-side) cities; hence, those cities could not be ignored, as right-sided landmarks can be when orally reporting from a mental image of a map or a map itself (e.g., Rode & Perenin, 1994; Rode, Rossetti, Perenin, & Boisson, 2004). The findings thus support the representational pseudoneglect hypothesis using a more robust method than recall from a mental image: For our task, subjects could not leave out any of the cities (as if they were unseen or unattended to); they had to estimate all of them. That they erred towards the west could be due to hyper-attentiveness to the left side or neglect of the right (or both); our data do not allow us to discriminate between these two. But as subjects could not ignore the eastern cities and they were definitely not too far to the east, this is a new kind of evidence for representational pseudoneglect because all the stimuli that were on the right side of space had to be dealt with, and on a continuous scale . Under this circumstance, it was *a priori* plausible that the Ottawans would err too far to the east, but they did not. The current location estimate task is thus a novel test for representational pseudoneglect because subjects *must* make an estimate to all the cities they are presented with, left and right. This implies that they must use explicit knowledge about eastern cities to perform the task.

These results provide support for the proposition that both phenomena affect large-scale geographic location estimates. The data thus add to the literature on the representation of geographic space because to our knowledge, no theory of geographical representation or processing (including our own) has taken account of representational pseudoneglect as a source of possible bias in location estimates. Further, the fact that the reference point hypothesis was true of the Ottawans diminishes the possibility that representational pseudoneglect is a purely implicit attentional phenomenon as has been shown in cases of actual neglect (Driver and Vuilleumier, 2001; Vallar, 1998; Della Sala et al., 2010). In the present case, paying explicit attention to the right-side of "memorial space" was required to respond to eastern cities. If the Ottawans had been inattentive or only implicitly attentive to eastern Canadian cities, they would not have been as likely to leave as much space between them as they actually did.

Thus, as far as we are aware, this is the first study to show representational pseudoneglect when subjects had to make responses to cities on the "neglected" side of space. The fact that they did so, and that the Ottawans showed a reference point effect for those cities, puts a bit of a different spin on the neglect phenomenon. That is, there was by all means a large western bias for easterners, but there was also some form of knowledge that was used to space the eastern cities relatively far apart. If Ottawans were responding by "reading" from an imagined map of Canada, they were certainly not completely ignoring the right side of that image. This finding also has implications for the representation of world geography and how we should interpret location estimates. For example, when estimating latitudes (both numerically and spatially), subjects appeared to use global landmarks (like the equator and the oceans) to divide the world into regions (Friedman, 2009; Friedman & Brown, 2000a,b). With longitudes and a spatial response mode, it appears that they may use higher level hemispatial processes as well as their home reference point to "parse" space from east to west. This implies that different processes or strategies can impact the same spatial estimation task in the same person and be responsible for different patterns of responding across individuals.

It should be noted that we and others have already shown that many factors affect geographical location estimates, including but not limited to global landmarks such as the oceans and the equator; what is learned throughout school and from other spoken and written sources; maps; attitudes towards others; and so on. Thus, it is possible in the present case that the relative sizes of the Atlantic and Pacific also influenced the east-west placement of the cities. However, were this the case, one might have imagined that the Baldwin illusion (Pressey & Smith, 1985) would come into play and cause an eastward bias by both groups, as the Pacific Ocean is vastly wider (about four times at the widest part) than the Atlantic. In the "pure" Baldwin illusion, a line flanked by two small squares is seen as longer than a line flanked by two large squares. In Pressey and Smith (1985), a large square and a small square are placed on each side of a correctly bisected line; the portion of the line that is next to the smaller square appears to be longer than that which is next to the larger square. Thus, the subjects either did not know that the Pacific is wider than the Atlantic or the relative sizes of the oceans did not play any notable role here.

It should also be emphasized that the present data support the notion that representational pseudoneglect and the reference point effect are different psychological mechanisms. Thus, to "correct" for the reference point effect would be wrong (and we would have to somehow make the same kind of corrections for latitudes, which would not correspond to any traditional analysis in either the psychological or geographical literatures). For example, correcting for the reference point effect would not explain the westward bias that existed for both groups for their respective home cities. Like Holyoak and Mah (1982), Bisiach and Luzzatti (1978), and Rode et al. (2009), and others, we believe that if we had asked our subjects to take a point of view from a different part of the country than where they lived, the form of the neglect would then shift accordingly. For example, if we had them imagine that they were looking at a map of North America from the North Pole, then eastern cities (which would be imagined on the left) should show the pseudoneglect bias (e.g., Rode & Perenin, 1994). Yet we would probably still see a reference point effect "surrounding" the home town of the subjects because they probably do know more about places they live in and near than other places. These predictions need to be addressed in future research.

An unexpected finding was that the two groups of subjects "parsed" their country differently from east to west. Ottawans put a relatively large distance between eastern Canada, the prairies, and the west coast. In contrast, Edmontonians had roughly three-four regions from west to east, and they were not spaced as far apart. We do not want to make much of this at this point because we did not measure attitudes towards "others", which have previously been shown to play a role specifically in distance estimates (Carbon & Leder, 2005) and map drawing (Lorenzi-Cioldi, Chartard, Marques, et al., 2011). However, it is an intriguing possibility that cannot be ignored in the investigation of any kind of visual neglect or geographical location estimates because with real-world knowledge (as opposed to line bisection), other factors besides perceptual ones may come into play in what is "seen" or not. On this view, it might be possible to ameliorate the amount of true visual hemispatial neglect shown in impaired individuals by asking them to remember affect-laden events associated with items on the neglected side of space. Evidence for such affect-triggered implicit knowledge has been reported in the clinical literature (Marshall & Halligan, 1988), and emotional cues can also shift the perceived midpoints of lines for healthy individuals (Mohr & Leonards, 2007). The quantitative method introduced here may encourage a more in-depth exploration of the interactions between emotions and space more generally (Tamagni, Mantei, & Brugger, 2009). In addition, recognition of reference point biases may enrich knowledge about both the behavioral neurology of the neglect syndrome and the processes underlying spatial location estimates.

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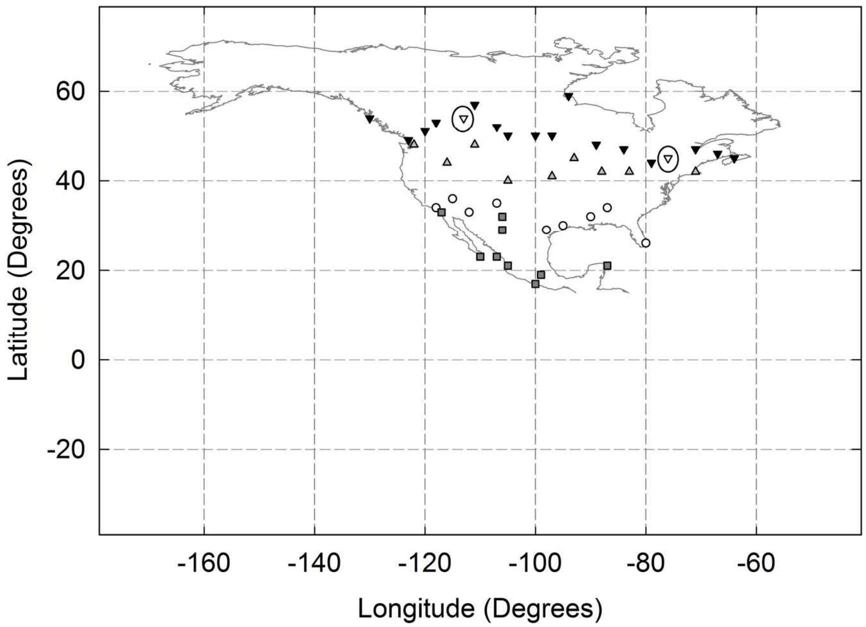
Figure Captions

Figure 1. The actual locations of the stimulus cities as a function of north-south region (Canada: black upside-down triangles; the northern U.S.: white right-side up triangles, the southern U.S.: white circles; and Mexico: grey squares). The upside-down white triangles in the approximate center of the two circles in Canada are, from west to east respectively, Edmonton, and Ottawa. Note that the figure is depicting only part of the stimulus array: The longitudes that appeared on each trial ranged from 0^o to 180^oW and the latitudes ranged from 90^oN to 40^oS.

Figure 2. The estimated locations of all the cities as a function of north-south region and group. The upside-down white triangles in the approximate center of the two circles in Canada are, from west to east respectively, Edmonton and Ottawa. The symbols are defined as in Figure 1. Error bars are standard errors of the mean across subjects for each city. Subjects did not see any maps during the study; the North American map is overlaid on the grid in this figure for reference only. Note that the figure is depicting only part of the stimulus array: The longitudes that appeared on each trial ranged from 0^o to 180^oW and the latitudes ranged from 90^oN to 40^oS.

Table 1. The stimulus cities and their actual latitudes and longitudes. The starred Canadian cities were used in the analyses related to the reference point effect.

Cities	Longitude (deg W)	Latitude (deg N)	Cities	Longitude (deg W)	Latitude (deg N)
Canada			Southern U.S.		
*Halifax	-64	45	Miami	-80	26
*Fredericton	-67	46	Birmingham	-87	34
*Quebec City	-71	47	Jackson	-90	32
*Ottawa	-76	45	Houston	-95	30
*Toronto	-79	44	San Antonio	-98	29
*Sault Ste Marie	-84	47	Albuquerque	-107	35
*Thunder Bay	-89	48	Phoenix	-112	33
Churchill	-94	59	Las Vegas	-115	36
Winnipeg	-97	50	Los Angeles	-118	34
Brandon	-100	50			
*Regina	-105	50			
*Saskatoon	-107	52			
*Fort McMurray	-111	57			
*Edmonton	-113	54			
*Jasper	-118	53			
*Kamloops	-120	51			
*Vancouver	-123	49			
*Prince Rupert	-130	54			
Northern U.S.			Mexico		
Boston	-71	42	Cancun	-87	21
Detroit	-83	42	Mexico City	-99	19
Chicago	-88	42	Acapulco	-100	17
Minneapolis	-93	45	Puerto Vallarta	-105	21
Lincoln	-97	41	Chihuahua	-106	29
Denver	-105	40	Ciudad Juarez	-106	32
Great Falls	-111	48	Mazatlan	-107	23
Boise	-116	44	Cabo San Lucas	-110	23
Seattle	-122	48	Tijuana	-117	33



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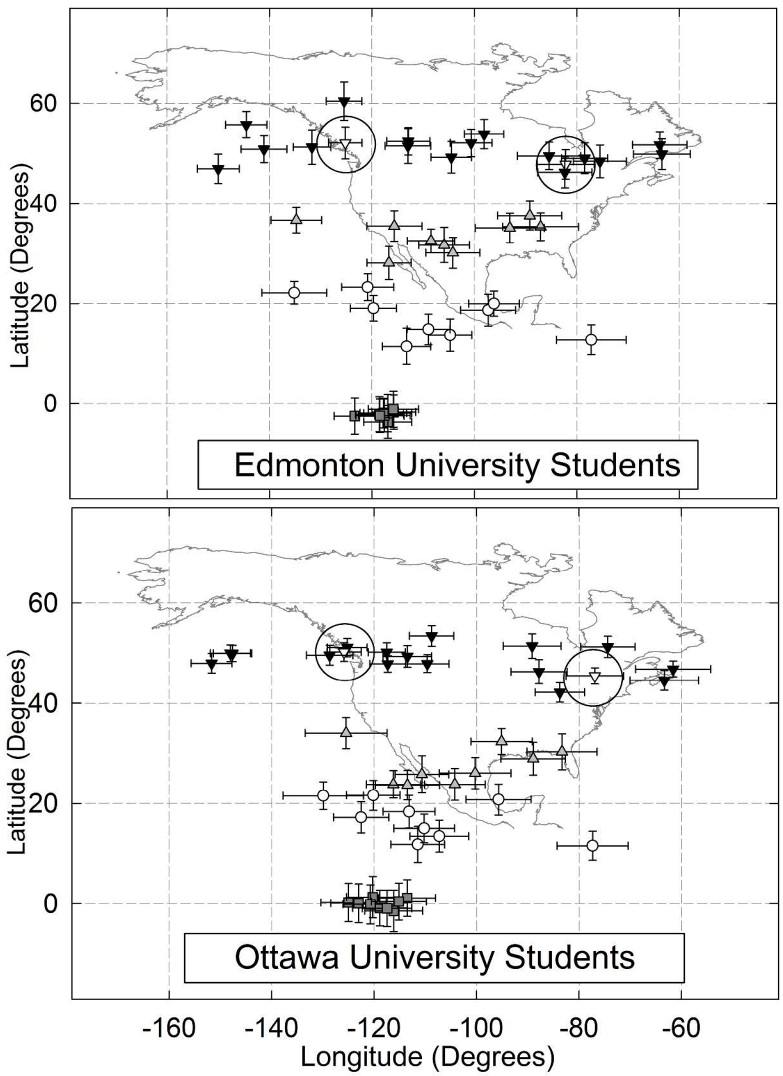

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